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PREDICTING ACHIEVEMENT IN TECHNICAL PROGRAMS AT THE NORTH DAKOTA STATE SCHOOL OF SCIENCE.

BY- ANDERSON, ROGER C.
NORTH DAKOTA UNIV., GRAND FORKS, COLL. OF EDUC.

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DESCRIPTORS- *ACADEMIC ACHIEVEMENT, ACHIEVEMENT TESTS, *PREDICTION, ACADEMIC APTITUDE, STUDENTS, *ACADEMIC PERFORMANCE, *TECHNICAL EDUCATION, COMPARATIVE ANALYSIS, NORTH DAKOTA STATE SCHOOL OF SCIENCE,

DATA WERE COLLECTED FROM SCHOOL RECORDS FOR 876 STUDENTS ENROLLED IN SIX TECHNICAL PROGRAMS FROM 1961-63. THIS PROVIDES EIGHT BIOGRAPHICAL AND 17 ACADEMIC VARIABLES WHICH WERE EXAMINED FOR THEIR USEFULNESS IN PREDICTING STUDENT SUCCESS. THE STUDENT SAMPLE WAS DIVIDED INTO GRADUATES AND NONGRADUATES. NONGRADUATES WERE THOSE WHO ATTENDED FOUR OR FEWER QUARTERS. SOME VARIABLES WHICH DIFFERENTIATED BETWEEN THE GROUPS WERE (1) COMPOSITE, MATHEMATICS, AND ENGLISH SCORES ON THE AMERICAN COLLEGE TEST (ACT), (2) GRADES IN HIGH SCHOOL MATHEMATICS, AND (3) CUMULATIVE GRADE POINT AVERAGE. ALL OF THESE CORRELATED RELIABLY WITH GRADE POINT AVERAGE FOR ELECTRONICS, ARCHITECTURAL DRAFTING, AND INDUSTRIAL DRAFTING PROGRAMS. BIOGRAPHICAL VARIABLES CORRELATED RELIABLY WITH THE GRADE POINT AVERAGE IN ONLY A FEW INSTANCES. THE BEST SINGLE PREDICTOR OF SUCCESS FOR EACH PROGRAM WAS -- (1) ACT NATURAL SCIENCE FOR ARCHITECTURAL DRAFTING, (2) ACT MATHEMATICS FOR CIVIL ENGINEERING, (3) HIGH SCHOOL MATHEMATICS FOR ELECTRICAL, (4) ACT COMPOSITE FOR INDUSTRIAL DRAFTING, (5) FLANAGAN APTITUDE CLASSIFICATION TEST (FACT) COMPONENTS FOR REFRIGERATION, AND (6) FACT INGENUITY FOR ELECTRONICS. (EM)

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Predicting Achievement in Technical Programs at the North Dakota State School of Science

Roger C. Anderson

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CENTER FOR RESEARCH IN
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ABSTRACT

Selected academic and biographical variables gathered from student records at the North Dakota State School of Science were subjected to four statistical analyses for six technical programs. A number of trainee characteristics were found to be reliably related to achievement in the technical programs. The results support the general findings of previous technical level prediction studies and tend to emphasize the importance of academic variables and secondary school preparation in traditional academic subjects. The results further substantiate the prevailing opinions that successful technical training presumes aptitudes in mathematics, science and English. Selected academic and biographical variables show promise of adding significantly to the prediction of achievement in selected technical programs.

INTRODUCTION

Recent writers in vocational guidance (Tyler, 1961; Wrenn, 1962) point out that college-bound high school students receive greater and more precise information on their chances of success than do their counterparts who plan to enroll in technical programs. The two groups of students have equal need to know the chances of success, but secondary school counselors and guidance personnel in technical schools have been handicapped by a lack of information concerning reliable predictors of success in technical education. The present study attempts to provide further information to vocational guidance and counseling personnel on the characteristics and the predictors of success of technically oriented students.

The primary interest of the study concerns the use of selected biographical and academic information in predicting achievement in the technical school. Answers to the following questions are sought:

1. Do technical program graduates and non-graduates differ on selected academic and biographical factors?
2. What is the relationship between academic and biographical factors and achievement in technical programs?
3. What is the relationship between a selected combination of academic and biographical variables and achievement in technical programs?
4. Is there a relationship between predicted and earned grade point average of technical program graduates?

RESEARCH DESIGN

The background factors and test information used in this study were gathered from school records at the North Dakota State School of Science at Wahpeton. The eight biographical and seventeen academic variables given in Table 1 represent the factors and information examined for predictive ability.

The sample consisted of 876 students who had enrolled from 1961 to 1963 in one of six technical programs at the State School of Science. Students who attended five quarters or more are categorized as "graduates", while students who were in attendance four quarters or less are categorized as "non-graduates". The breakdown on graduates and non-graduates is shown in Table 2.

Hypotheses

The questions examined may be stated as null hypotheses:

1. Technical program graduates and non-graduates will show no difference on selected academic and biographical variables.
2. Achievement, as measured by cumulative grade point average in one of six technical programs completed over a period of five quarters or more, will show no reliable relationship to either academic or biographical variables.
3. Achievement in technical programs will show no reliable relationship to a selected combination of academic and biographical variables.
4. Technical program students will show no reliable relationship between predicted and earned grade point average.

TABLE 1

Biographical and Academic Variables Employed

Biographical

1. Age at enrollment
2. High school graduation
3. Post high school education
4. Marital status
5. Military status
6. Parent's occupation
7. Home-town size
8. Cumulative grade point average (GPA)

Academic

American College Test (ACT)[1]

1. English
2. Mathematics
3. Social Studies
4. Natural Science
5. Composite score
   (Average of 4 educational development scores)

Flanagan Aptitude Classification Test (FACT)[1]

6. Reasoning
7. Vocabulary
8. Assembly
9. Components
10. Arithmetic
11. Ingenuity
12. Expression

Cooperative General Achievement Test (CGAT)[1]

13. Mathematics

High School Units

14. Mathematics
15. Science
16. Industrial Arts

17. Twelfth grade GPA

[1] Described in Appendix

TABLE 2

Number of Graduates and Non-Graduates
in Various Technical Programs

	Technical Program	Graduates	Non-Graduates
I.	Architectural Drafting	112	56
II.	Civil Engineering	48	23
III.	Electrical	103	62
IV.	Industrial Drafting	86	47
V.	Refrigeration	38	22
VI.	Electronics	186	93
	Total	573	303

RESULTS

Graduate and Non-Graduate Differences

The null hypothesis of no difference between graduates and non-graduates of the technical programs on selected academic and biographical factors was not tenable. The reliability of the differences between graduates and non-graduates was determined by a series of *t* tests on selected academic and biographical variables. Those variables examined and found to be reliably different for graduates and non-graduates appear in Table 3. In all cases where there were reliable differences the graduates were superior to the non-graduates.

On the American College Test mathematics is a consistently reliable differentiator for all six programs. English and the composite score differentiate betwee graduates and non-graduates in all programs except Civil Engineering.

The Flanagan Achievement Classification Test has less success than the ACT at distinguishing between graduates and non-graduates. The FACT's greatest success is for the Electrical programs where ingenuity, vocabulary, and components are all reliable differentiators.

Mathematics, as a high school unit, is again a good differentiator, but it is not as consistent across the six technical programs as is the student's cumulative grade point average.

Independent Biographical and Academic Variables

The null hypothesis is of no reliable relationship between academic and biographical variables and achievement in the technical programs was not tenable. To determine the presence of a reliable relationship, Pearson correlation coefficients were obtained between individual predictor

TABLE 3

Summary Table of Selected Academic Variables Indicating Reliable Differences Between Graduates and Non-Graduates

	Technical Programs[1]					
	I	II	III	IV	V	VI
	N	N	N	N	N	N
American College Test						
English	45 *	14	53 *	36 *	17 *	67 *
Mathematics	45 *	14 *	53 *	36 *	17 *	67 *
Social science	45	14	53 *	36 *	17 *	67 *
Natural science	45	14	53 *	36	17 *	67 *
Composite score	45 *	14	53 *	36 *	17 *	67 *
Flanagan Achievement Classification Test						
Reasoning	47		56	40	18	75
Assembly	43			39 *		
Arithmetic	44 *			40		
Ingenuity	47		57 *	40	18	75 *
Expression	41			38 *		
Vocabulary			57 *		18	73
Components			54 *		18 *	73 *
High School Units						
Mathematics	45 *	14 *	53 *	36	17	67 *
Science	45 *	14	53 *	36	17	67
Industrial arts	45	14	53	36	17	67
12th grade GPA	25	13	27 *	22	8	38
Cumulative GPA	45 *	14 *	53 *	36 *	17 *	67 *

* Reliable at the .05 level

[1] Technical Programs' names appear in Table 2

variables and technical program grade point average. The results for the academic variables examined are shown in Table 4. All five of the American College Test (ACT) components correlate reliably with grade point average for technical programs of Electronics, Architectural Drafting, and Industrial Drafting. No more than one ACT component shows reliable predictive value for the other three programs. Five Flanagan Achievement Classification Test (FACT) components correlate reliably with grade point average for the Architectural Drafting program. The FACT shows diminishing predictive success with the Electronics, Electrical, and Refrigeration programs, in that order, and no reliable predictive value for the remaining programs. Mathematics, science, and twelfth grade GPA are of some value as predictors for the Electrical and Electronics programs.

The results for the biographical variables appear in Table 5. In only a few instances do the biographical variables correlate reliably with the grade point average criterion. Age, military status and post-high school education show some predictive value, but for no more than two technical programs each.

Combined Biographical and Academic Factors

The null hypothesis of no reliable relationship between a combination of selected academic and biographical variables and grade point average in technical programs was rejected. Table 6 gives the variables included in the predictive equation for each program. The variables included were those which correlated .10 or higher with the criterion.

The R shown in Table 6 represents the multiple correlation of variables beginning with the best predictor, and then, subsequently, adding the next best predictor. For example, in the Architectural Drafting program the best one predictor is ACT natural science, with an R of .50.

TABLE 4

Correlation Coefficients Between Selected Academic Variables and Graduate Grade Point Average

	Technical Programs[1]											
	I		II		III		IV		V		VI	
	N	r	N	r	N	r	N	r	N	r	N	r
American College Test												
English	88	.36†	40	.19	88	.07	74	.26*	33	.13	145	.17*
Mathematics	88	.46†	40	.23	88	.27*	74	.36†	33	.27	145	.26†
Social science	88	.42†	40	.13	88	.17	74	.27*	33	.32	145	.21†
Natural science	88	.51†	40	.08	88	.15	74	.28*	33	.14	145	.29†
Composite score	88	.55†	40	.22	88	.20	74	.36*	33	.38*	145	.29†
Flanagan Achievement Classification Test												
Reasoning	90	.21*			91	.03	71	.03	37	-.09	175	.16*
Assembly	90	.30†					71	.15				
Arithmetic	90	.44†					71	.19				
Ingenuity	90	.38†			91	.32†	71	.16	37	.29	175	.28†
Expression	90	.32†					71	.16				
Vocabulary					91	.12			37	.04	175	.12
Components					91	.41†			37	.42†	175	.29†
High School Units												
Mathematics	112	.06	48	-.19	103	.37†	86	.14	38	.09	182	.15*
Science	112	.16	48	.05	103	.19*	86	.17	38	.39*	182	.04
Industrial arts	112	-.05	48	-.01	103	-.08	86	-.12	38	-.17	182	.06
12 grade GPA	43	.48†	23	.09	52	.29*	39	.41	18	.27	79	.26*
Cooperative General Achievement Test												
Mathematics			41	.14								

* Reliable at the .05 level
† Reliable at the .01 level

[1] Technical Programs' names appear in Table 2

TABLE 5

Correlation Coefficients Between Selected Biographical Variables and Graduate Grade Point Average

	Technical Programs[1]											
	I		II		III		IV		V		VI	
	N	r	N	r	N	r	N	r	N	r	N	r
Age of Student	112	.23†	48	.10	103	.16	86	.20	38	.20	182	.17*
H.S. Graduation	112	.03	48	.11	103	.14	86	.13	38	.29	182	.01
Marital status	112	.10	48	-.20	103	.11	86	.10	38	.27	182	.13
Post High School Education	112	.01	48	.11	103	.22*	86	.20	38	.25	182	.14*
Military status	112	.16	48	.15	103	.17	86	.29†	38	.43†	182	.09
Parent's occupation	112	.07	48	.07	103	-.14	86	-.03	38	-.10	182	-.02
Home town size	112	.07	48	-.09	103	-.15	86	.01	38	-.17	182	.10

* Reliable at the .05 level
† Reliable at the .01 level

[1] Technical Programs' names appear in Table 2

TABLE 6

Summary of the Multiple Correlation Analyses
For the Six Technical Programs

	Technical Programs	Predictor Variable	R
I.	Architectural Drafting (N = 72)	ACT[1] natural science	.50
		FACT[2] arithmetic	.64
		ACT mathematics	.66
		FACT expression	.67
		Units of science	.70
II.	Civil Engineering (N = 33)	ACT mathematics	.21
		Military status	.41
		Marital status	.53
III.	Electrical (N = 82)	Units of mathematics	.37
		Military status	.53
		FACT components	.63
IV.	Industrial Drafting (N = 61)	ACT composite	.33
		Military status	.45
		FACT arithmetic	.51
V.	Refrigeration (N = 32)	FACT components	.40
		Units of industrial arts	.55
		Military status	.64
		ACT composite	.73
IV.	Electronics (N = 136)	FACT ingenuity	.28
		ACT natural science	.36
		Age	.40
		FACT reasoning	.43
		Home-town size	.44
		Units of mathematics	.47

1 American College Test
2 Flanagan Aptitude Classification Test

Using the best two predictors yields an R of .64. Using the best five predictors yields an R of .70. Interpretive information of this final R appears in Table 7. Quite clearly, the ability to predict grades by multiple regression procedures differed for each of the six technical programs.

Grade Point Average

A cross validation procedure yielded the coefficients shown in Table 8. These coefficients were produced by use of a Pearson correlation analysis to test the fourth hypothesis as to the degree of relationship between the predicted and the earned grade point averages of technical program graduates.

Reliable correlations were found between predicted and earned grade point average for the Electrical, the Industrial Drafting, and the Electronics programs. For these three programs, the null hypothesis was rejected.

TABLE 7

Multiple Correlation Summary For Technical Programs At The North Dakota State School of Science

	Technical Programs	Multiple R	Corrected R (Rc)	Standard Error of Estimate of Rc	Coefficient of Determination Rc^2	Standard Error of Rc
I.	Architectural Drafting	.70	.68 †	.35	.46	.00
II.	Civil Engineering	.53	.50 *	.44	.25	.01
III.	Electrical	.63	.62 †	.42	.38	.07
IV.	Industrial Drafting	.51	.50 *	.43	.25	.09
V.	Refrigeration	.73	.70 †	.41	.49	.09
VI.	Electronics	.47	.44 †	.55	.19	.07

* Reliable at the .05 level
† Reliable at the .01 level

TABLE 8

Correlations Between Earned Grade Point Averages and Predicted Grade Point Averages of Technical Program Graduates

Technical Programs	N	r
I. Architectural Drafting	16	.46
II. Civil Engineering	25	.18
III. Electrical	33	.38 *
IV. Industrial Drafting	24	.71 †
V. Refrigeration	6	.58
VI. Electronics	43	.31 *

* Reliable at the .05 level
† Reliable at the .01 level

DISCUSSION

The results of this study agree with those of previous studies (Gwydir, 1957; Halsey, 1957) which emphasize the importance of academic variables and high school preparation in traditional academic subjects as predictors of achievement in technical training. The present study finds that a number of trainee characteristics exist which are, singularly or in combination, reliably related to satisfactory achievement.

Greenwood (1962), in an attempt to identify selection standards for three technical curricula, concluded that separate selection standards are needed for each curriculum and that selection standards should be flexible. In the present study, as well, the need for flexible selection standards is apparent. The predictive effectiveness of specific variables varied greatly for each technical program.

The range of multiple correlations of the present study (.44 to .70) closely parallels that of Libby (1963) for industrial technicians. The results of the present study lend support to the conclusions of Libby and of Hoyt (1966) that the American College Test provides a useful predictive index for technically oriented students. The three most useful predictors from the American College Test were the composite, mathematics, and natural science.

No technical level studies were found in the literature where the Flanagan Achievement Classification Test was used to predict achievement. It was possible in this study to explore the usefulness of the FACT as a predictor of satisfactory achievement. It should be noted that not all students received this test. Subtests of the FACT were given to students in selected technical programs. The seven selected subtests of the FACT which were administered to Technical Division students at the time of

enrollment are listed in Table 2.

The results of the FACT battery confirm the American College Test findings that mathematics and English skills are related to achievement in technical training. In addition, the FACT battery provided several dimensions related to achievement. FACT components—a measure of abstract reasoning—contributed reliably to the prediction of achievement in the Electrical and Refrigeration technical programs, while FACT Ingenuity—a measure of creative or inventive skill—contributed reliably to the prediction of achievement in the Electronics technical program. Similarly, Halsey (1957) has found that the DAT Mechanical Reasoning subtest contributes reliably to the prediction of grade point average for freshmen in a technical level curriculum. The present study adds further support to this finding that special aptitudes are related to trainee success at the technical level.

While predictive effectiveness of the biographical variables is limited, a number of these variables made a significant contribution to the prediction of satisfactory achievement. Included, either singularly or in combination, in five of the six prediction equations were the biographical variables of age, military status, marital status, and community population, which is the population of the student's home town, as given by the 1965 Rand McNally Atlas.

The most consistently useful biographical variable for predicting achievement was military status. This is not surprising considering the high intercorrelations of military status, marital status, and age. Considerable overlap exists among these variables in terms of the criterion variance they are able to explain.

CONCLUSIONS

The findings of this study supported the following conclusions:

1. Technical program graduates have more preparation in mathematics and, in general, score higher on the American College Test than do non-graduates.
2. Academic variables show appreciably higher relationships with achievement in technical programs than do biographical variables.
3. The graduates of certain technical programs possess greater special aptitude skills (space relations, abstract reasoning, and creative and inventive problem solving) than do non-graduates.
4. The ability to predict grades by multiple regression procedures differed for each of the six technical programs.

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APPENDIX

American College Test (ACT)

Founded in 1959, the American College Testing Program was designed to be especially useful to college officials responsible for admissions, course sectioning, advanced placement, scholarship and loan programs and student counseling. Although intended primarily for use with college-bound youth, there is some evidence that the ACT may be a valid measure for predicting the achievement of technical students.

The basic test battery consists of four subtests: English, mathematics, social studies, natural science, and a composite score. The composite score for this battery is an average of four educational development scores. Measures of internal consistency yield median reliabilities ranging from .84 for a single test to .95 for the composite score. The median predictive validity of individual ACT tests range from .37 to .50.

Flanagan Aptitude Classification Test (FACT)

The FACT was designed to provide a prediction of success in educational courses and occupations. The first published edition was issued in 1953. The present FACT battery consists of 19 sub-tests combined into 38 composites; 22 relate to college occupations and 17 relate to non-college careers. The job element approach based on "critical behaviors" rated by experts provided the rationale for the battery.

The original correlation studies for technical fields showed validity coefficients significant at the one percent level for electrician, mechanic, machinest, plumber and draftsman-printer. The equivalent form reliability coefficients for nine representative combined scores ranged from .83 to .93 with a median of .87 for the initial 14 subtests of the battery.

Cooperative General Achievement Test—Mathematics (CGAT)

The CGAT, first published in 1937, provides a measure of general mathematics proficiency at the twelfth grade or college freshmen level. Part I of the test contains items distributed over arithmetic, algebra, plane geometry and trigonometry. Part II contains items based on tables, graphs, reading passages and diagrams. Reliability coefficients range from .82 to .92.